BIOLOGICAL EVALUATION OF GYPSY MOTH

at

LAKEHURST NAVAL AIR ENGINEERING CENTER

2008

Prepared by

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ABSTRACT

On November 17, 2008, USDA Forest Service personnel conducted a gypsy moth egg mass survey at Lakehurst Naval Air Engineering Center. The purposes of this survey were to evaluate the efficacy of this year's treatment, determine gypsy moth population densities, assess the potential for defoliation and the need for treatment in 2009. Current populations are sufficient to cause defoliation on 420 acres. Treatment is recommended to prevent defoliation, branch dieback and possible tree mortality.

METHODS

Gypsy moth survey plots were randomly selected based upon available host trees (oak species), size of sample area and uniformity between egg mass counts. At each sample point, a $1/40^{th}$ acre fixed radius plot was established. The plots consisted of a tally of all the new (2008) egg masses observed on the overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was multiplied by 40 to determine the number of egg masses per acre. Egg mass lengths were measured at the plots to determine the overall "health" of the existing population and as a measure of egg mass fecundity.

RESULTS

The location of the survey plots along with the 2008 treatment areas are shown in Figure 1. The summarized results of the survey are presented in Table 1. In brief, egg mass densities ranged from 0-7160 and averaged 851 egg masses per acre. Overall egg mass lengths tended to be small to moderate in size, ranging from 12-36 mm and averaging 24 mm.

The results of this years' suppression project were good. A single application of *Bacillus thuringienis* variety *kurstaki (Btk)* was applied on 1060 acres during May 19 and 20. Egg mass densities in the treatment areas have been reduced 88.9% from the pre-treatment (2007) level of 10,777 egg masses per acre to the current level of 1203 egg masses per acre. Foliage protection was provided for over 99.9% of the treatment areas as only .8 of an acre of defoliation was detected in the treatment areas during the aerial survey conducted on June 18 (Figure 2).

DISCUSSION

The basic guidelines used to evaluate the risk of defoliation include: previous defoliation events; number of egg masses/acre; size and condition of the egg masses; available preferred food; and risk of larval blow-in following egg hatch. Potential defoliation is categorized as; light (30-50 percent) and heavy (51-100 percent). Defoliation less than 30 percent has little impact on trees and cannot be detected through aerial surveys.

The egg mass survey results indicate that light defoliation (30-50 percent) is likely to occur in five areas totaling 322 acres and heavy defoliation (51-100 percent) is likely to occur on 98 acres at Lakehurst Naval Air Engineering Center in 2009 (Figure 3).

This defoliation prediction is further supported when egg density is also used as a means of estimating gypsy moth population densities. Moore and Jones (1987) found that estimating the mean fecundity would increase the precision of gypsy moth density estimates and that a linear relationship exists between egg mass length and fecundity.

Further work by Liebhold et al., (1993) demonstrates that the product of the mean egg mass length (in mm) and egg mass density provides a more precise means of estimating population densities and prediction defoliation. Using Liebhold's model, Figure 4, shows how this information can be used to correlate the predicted defoliation of an area. Accordingly, the estimated egg mass density of 4433 masses per acre (average egg mass density in the area located around the golf course x 24 mm (average egg mass length in this area) translates to a projected defoliation level of about 78 percent (heavy defoliation). Because egg mass densities and the host type are not evenly distributed, actual defoliation will vary from tree to tree but will be predominately heavy throughout the golf course. Light defoliation is predicted for the other five areas identified in Figure 3.

Based on existing egg mass densities and the general size of egg masses, gypsy moth populations appear to be declining throughout most areas surveyed at Lakehurst Naval Air Engineering Center. The overall average egg mass length is 24 mm. The average egg mass length has declined each of the last 3 years as it averaged 29 mm in 2005, 28 mm in 2006, 27 mm in 2007 and currently is 24 mm. Egg mass lengths in the six areas where defoliation is expected average 26 mm. Egg masses larger than 25 mm typically indicate healthy populations with no obvious stress from either the gypsy moth nucleopolyhedrosis virus (NPV) or the *Entomophaga maimaiga* fungus, two of the primary natural control agents that often express themselves in declining or stressed populations. Although gypsy moth populations in several areas in the base appear to be stressed as these egg mass average less than 25 mm, there was no evidence that either one of these entomopathogens had significant impacts at Lakehurst Naval Air Engineering Center in 2008. It is likely that either the gypsy moth fungus or the NPV could cause the collapse of the gypsy moth populations in 2009. However, the collapse may take place after a defoliation event has occurred.

Predicting the extent of tree mortality that would occur after one year's defoliation is difficult, however, a stand of trees that is not stressed by other agents during or immediately following a single heavy defoliation will likely pull through with only minor branch dieback and minimal mortality. Trees that are defoliated in excess of 60 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate, and consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the time of defoliation, reduced growth, mast abortion, branch dieback or in some cases tree mortality, has occurred following a single year of heavy defoliation. Should subsequent defoliation occur the

following year, the impact is compounded. Trees that receive light defoliation (<50 percent) are not likely to refoliate and there is probably no significant impact other than a reduction in growth, reduction of mast and possibly some minor branch dieback.

Trees at greater risk are those that are presently stressed from other factors, such as soil compaction from roads, sidewalks, parking lots, machinery and/or heavy foot travel; over maturity; drought; shock due to recent timber cutting activities; previous year(s) defoliation; and other insect and disease related problems. Lakehurst Naval Air Engineering Center experienced a severe drought during the 2007 growing season, and again late in the 2008 growing season. Approximately 82 acres of defoliation were detected at Lakehurst Naval Air Engineering Center in 2006, 39 acres were detected in 2007 and 120.4 acres in 2008.

The Allegheny National Forest (1988) and the West Virginia Division of Forestry (1997) provide examples of the potential tree mortality that can occur. On the Allegheny National Forest, untreated stands consisting of 40-80 percent oak, the average loss of basal area (mainly oaks) was about 16 percent (range 3-28 percent) following one year of defoliation and 26 percent (range 10-43 percent) after two consecutive years of defoliation. In a 1986 study area in eastern West Virginia where oak species accounted for 63-78 percent of the species composition, a loss of 25 percent of the total oak saw timber and 14 percent of the total oak pole timber occurred after one year of moderate to heavy defoliation. In these examples, droughty conditions likely contributed to the level of mortality.

Based on observations of the existing health of the forested areas at Lakehurst Naval Air Engineering Center and the factors mentioned above, scattered areas of tree mortality are expected if defoliation occurs. Mortality will be more severe if adequate rainfall is not received during the 2009 growing season and/or if the defoliation occurs in areas that have been previously defoliated.

Management Options

In 2009, three management options have been evaluated for managing gypsy moth populations at Lakehurst Naval Air Engineering Center. The intervention options are offered based upon the following two treatment objectives: 1) protect host tree foliage to prevent mast failure, branch dieback and tree mortality; and 2) reduce gypsy moth population below the treatment threshold. Each is discussed below.

No Action Option

It is possible that gypsy moth populations could collapse on their own due to the presence of nucleopolyhedrosis virus (NPV) or the more recently recognized fungal pathogen, *Entomophaga maimaiga*. In areas with defoliating levels of gypsy moth populations, viral epizooics generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach levels and then collapse as a result of NPV or fungal activity. Residual populations following

such a collapse will likely remain at low densities for 3-6 years before rebuilding to defoliating levels.

Although it is not possible to accurately assess such events with the defoliating levels and then collapse as a result of NPV or fungal activity. Residual populations information at hand, it is unlikely that a collapse will occur in 2009 prior to a significant defoliation event.

Large numbers of gypsy moth caterpillars and defoliation has been shown to impact competing native herbivore arthropods. Sample et al., (1996) showed short-term impacts of both species richness and abundance occurred following light to moderate defoliation events in study plots in West Virginia. It is likely that impacts would be greater as the size of the area and intensity of defoliation increases and be more long term, should extensive tree mortality occur.

Should this option be selected, it is likely that light and heavy defoliation will occur in several areas of Lakehurst Naval Air Engineering Center in 2009 (Figure 3).

Microbial Insecticide Option

***Btk*:** The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide *Bacillus thuringienis* variety *kurstaki (Btk)*. This insecticide is available through several manufacturers and has been used extensively in suppression projects throughout the U.S. in both forested and residential areas. *Btk* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *Btk* is persistent on foliage for about 7-10 days.

Btk has been shown to impact other non-target caterpillars that are actively feeding at the time of treatment. An example of the potential impacts is provided by a study conducted by Miller (1990) in Oregon and Samples, et al., (1996) in West Virginia. Miller's study involved a large scale (5,000 acres) eradication program where three consecutive applications of *Btk* were applied within a single season. On Garry oak, Miller found that species richness was significantly reduced in treated areas during all 3 years of the study while the total number of immature native Lepidoptera rebounded after the second year. In the Sample study, the areas treated with *Btk* were 50 acre plots and only a single treatment applied. Here too, both species richness and the total numbers of native macro-lepidopterous caterpillars and adults were reduced but only for less than 1 year. The difference in duration of the impacts between these studies is probably the result of the number of treatment applications applied and the size of the treatment area involved.

Btk formulations are available as flowable concentrates, wettable powders, and emulsifiable suspensions. The normal application rates range from 24-36 billion international units (BIUs) per acre in a single or double application. *Btk* can be applied either undiluted or mixed with water for a total volume of ½ -1 gallon per acre. With

proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely.

Because *Btk* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

Gypchek: A second microbial insecticide that is registered and available in limited quantities is the formulated nucleopolyhedrosis virus called Gypchek. This product is not available commercially but is produced in limited quantities by a cooperative effort of the USDA Forest Service and the Animal Plant Health Inspection Service (APHIS). The active ingredient in Gypchek formulations has a very narrow host range (lymnatriids) and occurs naturally in gypsy moth populations. Normally the virus reaches epizootic proportions when gypsy moth populations reach high densities as a result of increased transmission within and between gypsy moth generations. The application of Gypchek to gypsy moth populations simply expedites this process by increasing the exposure of the virus at an earlier stage. Healthy, feeding gypsy moth caterpillars become infected by ingesting contaminated foliage and soon stop feeding and die.

The efficacy of Gypchek treatments to reduce gypsy moth populations has been quite variable. Because of the short period of viral activity on foliage (3-5 days) as well as other biological factors such as feeding activity and weather conditions, it has been difficult at best to project treatment efficacy. Most often foliage protection can be achieved but significant reductions in gypsy moth densities do not always occur. Should inadequate population reduction occur, areas would need to be treated again the following year.

The normal application rate of Gypchek is 4×10^{11} occlusion bodies (OB's) per acre applied in a single application or 2×10^{11} OB's per acre applied in a double application. Due to the limited supply, priority is first given to state and federal cooperators that need to deal with federally listed threatened and endangered species associated with gypsy moth treatments. There are, however, sufficient quantities of Gypchek currently available for 2009 should this insecticide be preferred for use at Lakehurst Naval Air Engineering Center.

Chemical Insecticide Option

The third option is to use a chemical insecticide to control gypsy moth populations. There is currently one chemical insecticide registered for control of gypsy moth populations and approved by the USDA Forest Service for use in cooperative gypsy moth control programs.

Dimilin ® (diflubenzuron) is the most widely used chemical insecticide in gypsy moth suppression projects in the U.S. Diflubenzuron (DFB) is an insect growth regulator that

disrupts the normal molting processes of the larvae. The mode of action is to inhibit the formation of the molt following treatment. The method of uptake is primarily by ingestion, however. Some research has indicated the possibility of absorption through the cuticle as well. DFB is relatively persistent on foliage (24 days) which increases the efficacy on gypsy moth populations but also exposes non-target insects, particularly caterpillars, for a greater period of time.

Dimilin® is registered by EPA for use in residential and forested areas. It is, however, extremely toxic to some aquatic invertebrates and the label prohibits the application over open water or wetlands. DFB is available as an oil based liquid formulation (Dimilin® 4L) and is normally applied in a single application at the standard rate of 1-2 ounces of formulated material per acre. With proper application, foliage protection and a significant population reduction can be expected. The need for treatment of residual populations the following year is normally not necessary.

Alternatives

With the previously described options in mind, the following alternatives are offered:

Alternative 1. - No action.

Alternative 2. - One aerial application of *Btk* at the rate of 36 BIUs in a total mix of ½-¾ gallon per acre.

Alternative 3. - Two aerial applications of *Btk*, as in alternative 2, applied 4-7 days apart.

Alternative 4. - One aerial application of Gypchek at the rate of 4×10^{11} OB's in a total mix of 1 gallon per acre.

Alternative 5. - Two aerial applications of Gypchek at the rate of 2×10^{11} OB's in a total mix of 1 gallon per acre, applied 3-5 days apart.

Alternative 6. - One aerial application of DFB at the rate of 0.75 oz formulated material in a total mix of 1 gallon per acre.

RECOMMENDATIONS

As previously stated, gypsy moth populations are sufficient at Lakehurst Naval Air Engineering Center to cause light defoliation on 322 acres and heavy defoliation on 98 acres. To protect tree foliage and prevent branch dieback and possible tree mortality, our recommendation is alternative 2 (a single application of *Btk*).

This recommendation is based on the following considerations:

1) It is likely that a single application of *Btk* will provide foliage protection and a significant population reduction against a stressed population.

2) A single application of *Btk* is more economical than a double application of *Btk*.

3) A single or double application of Gypchek is less likely to provide both adequate foliage protection and sufficient population reduction.

4) Due to the toxicity of DFB to some aquatic invertebrates, and with streams, ponds and wetlands in some of the proposed treatment areas, alternative 6 (aerial application of DFB) was eliminated from consideration.

If defoliation and subsequent mortality would not interfere with the management objectives of an area(s) where defoliation is expected, we would recommend Alternative 1 (no action) in this area(s).

REFERENCES

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West Virginia Division of Forestry. 1997. *In* 1997 Cooperative State-County-Landowner Gypsy Moth Suppression Program in West Virginia. 3p. (Brochure).

Table 1 - Results of the gypsy moth egg mass survey conducted at Lakehurst Naval Air Engineering Center, November 17, 2008.

Plot #	# em acre	em size (mm)	Plot #	# em acre	em size (mm)
1[x*]	1160	30, 22, 26	19[x]	160	--
2[x]	400	24	20[x*]	1760	24,26, 26
3	320	--	21[*]	1240	36, 30, 24
4[x]	360	20	22[x]	120	24
5[x]	120	22	23[x]	280	28
6[x]	360	28, 22	24[*]	2120	22, 22, 24
7	400	36	25[*]	680	24, 22
8[x]	320	12, 14	26[x*]	7160	26, 24, 24
9[x]	440	26	27[x*]	2920	24, 22
10[x]	0	--	28[x*]	3280	24, 26, 24
11	320	16, 26	29	400	22
12	0	--	30	120	--
13	0	--	31[*]	2440	36, 24, 24
14[x]	400	24, 28	32	360	24
15[x]	360	16,18	33	200	24, 22
16	80	24	34[*]	1120	28, 26, 24
17	0	--	35	360	22
18	40	24			

overall em/acre range = 0-7160
overall em/acre average = 851

overall em size range (mm) = 12-36
overall em size average (mm) = 24

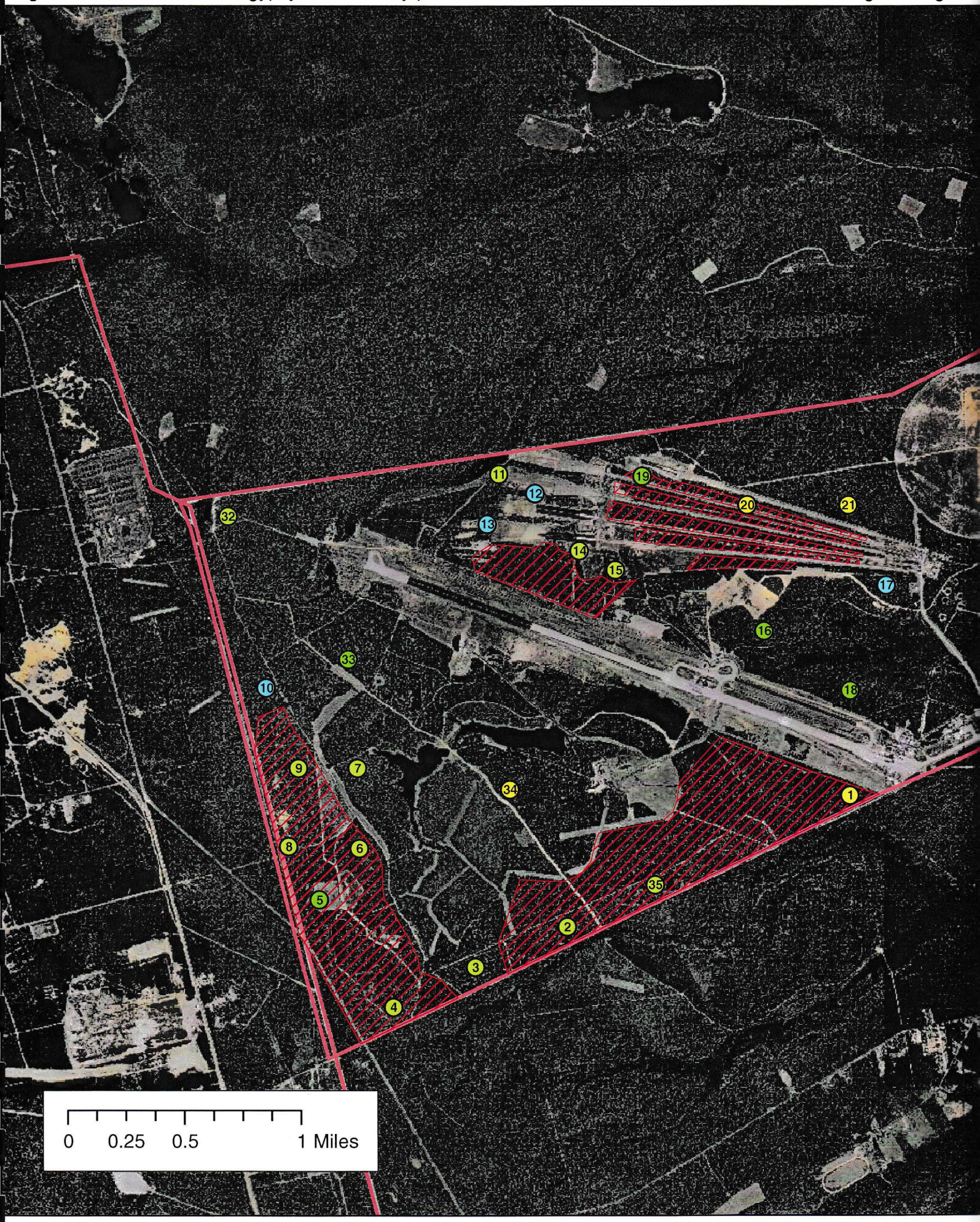
[x] = plot located in 2008 treatment area
em/acre range in 2008 treatment areas = 0-7160
em/acre average in 2008 treatment areas = 1203

em size range (mm) in 2008 treatment areas = 12-36
em size average (mm) in 2008 treatment areas = 24

[*] = plot located in recommended treatment area
em/acre range in recommended treatment areas = 680-7160
em/acre average in recommended treatment areas = 2338

em size range (mm) in recommend treatment areas = 22-36
em size average (mm) in recommend treatment areas = 26

Figure 1. -- Location of the gypsy moth survey plot locations established at Lakehurst Naval Air Engineering Cer



enter on November 17, along with the 2008 treatment areas.

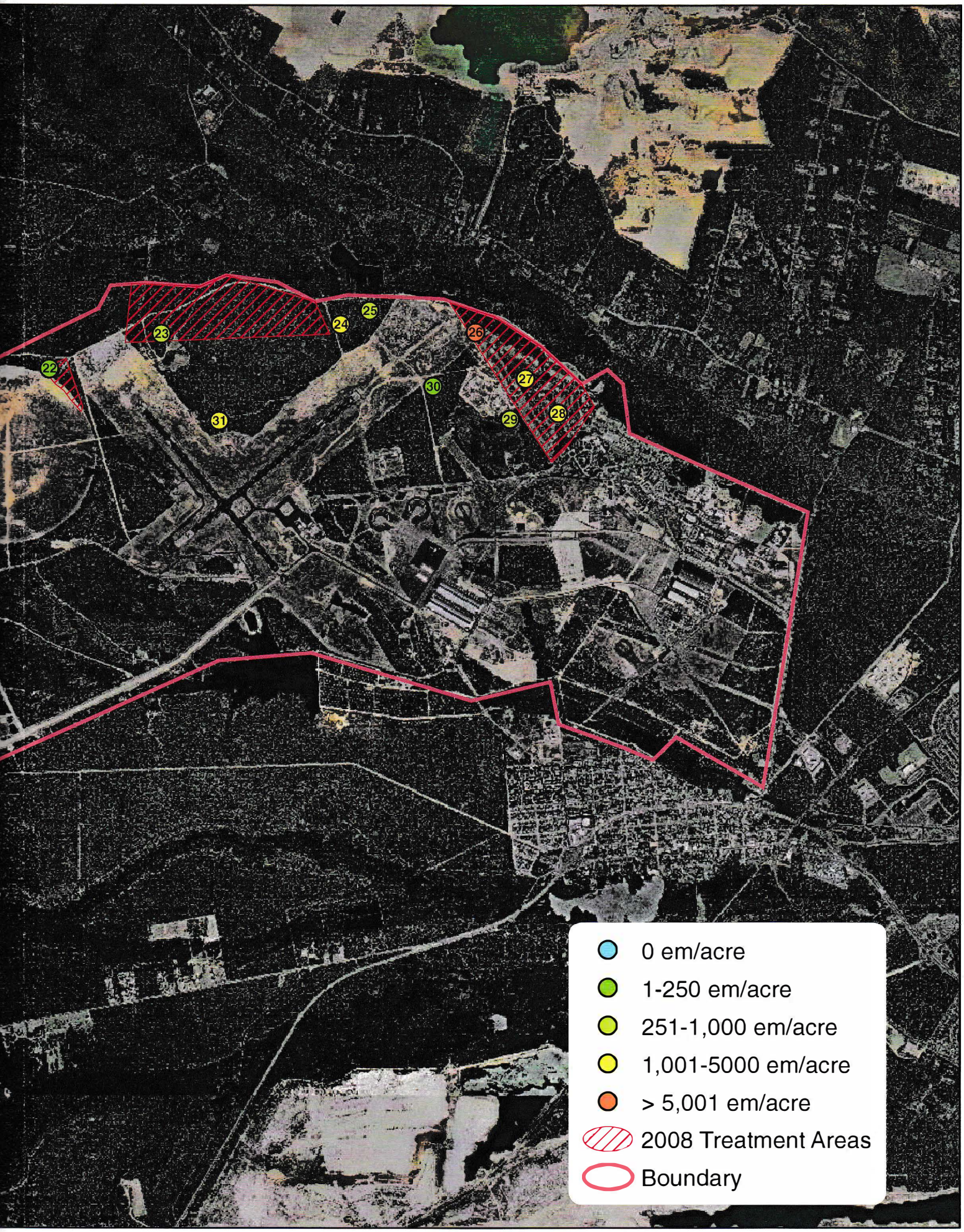
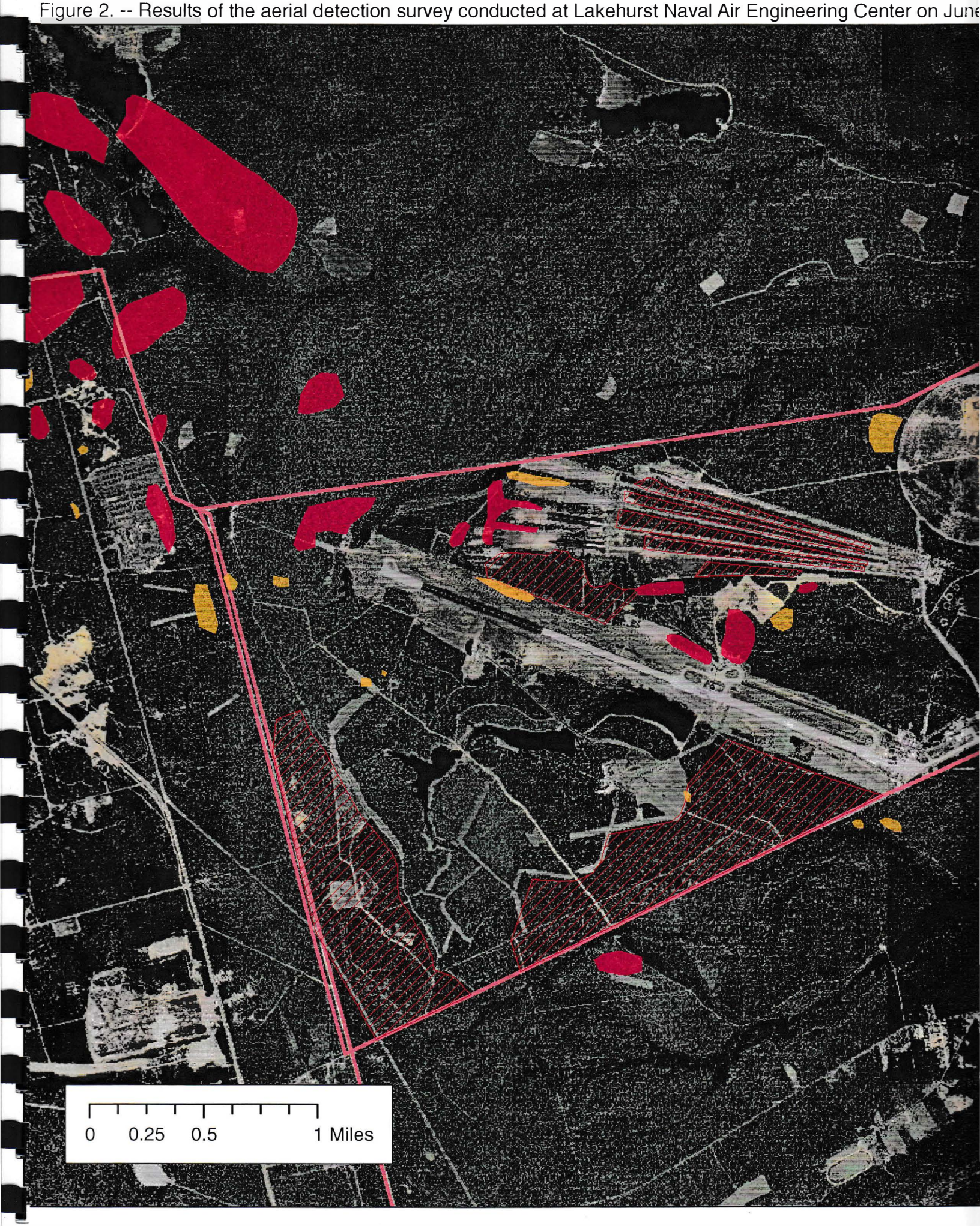


Figure 2. -- Results of the aerial detection survey conducted at Lakehurst Naval Air Engineering Center on June



e 18, along with the 2008 gypsy moth treatment areas.

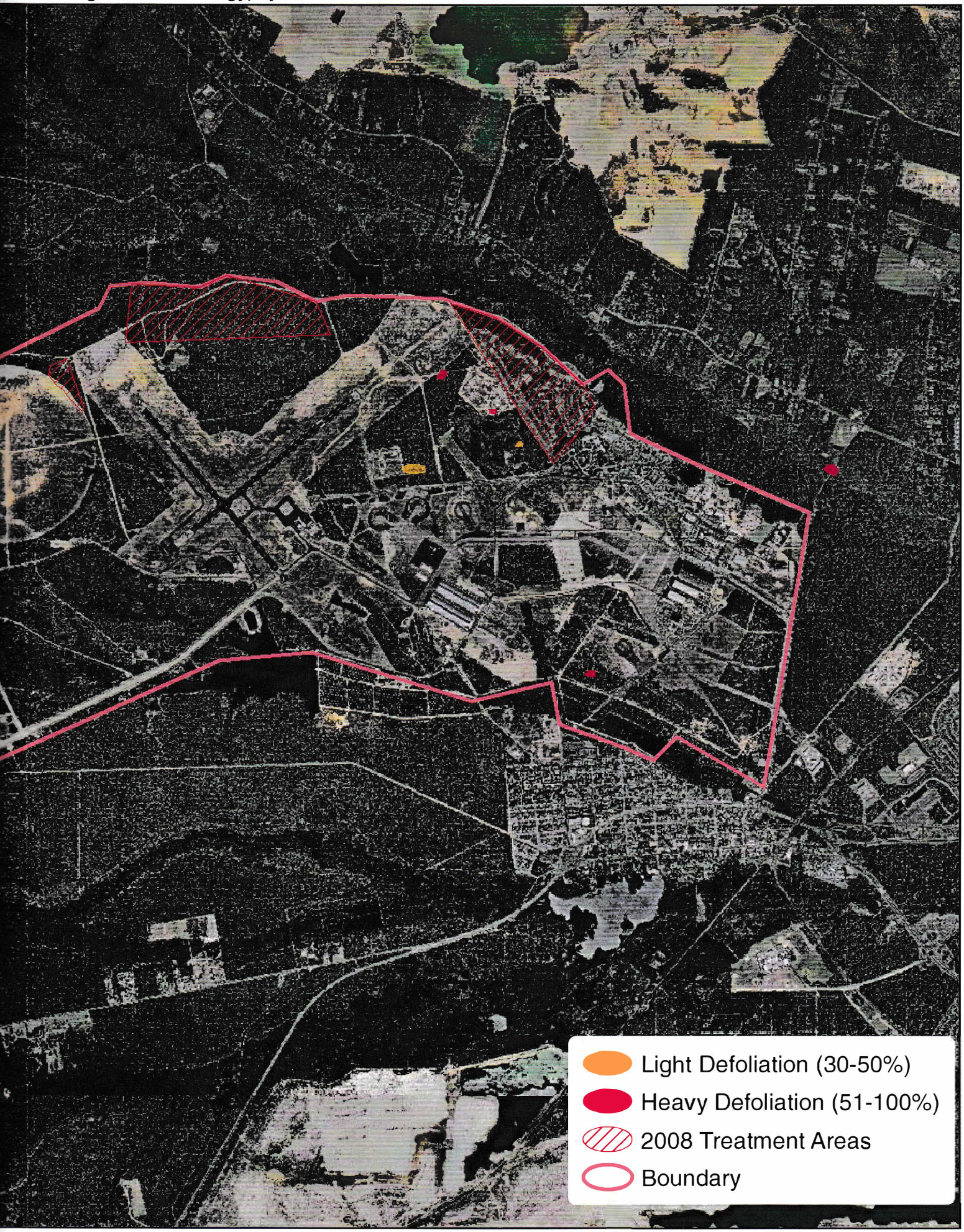
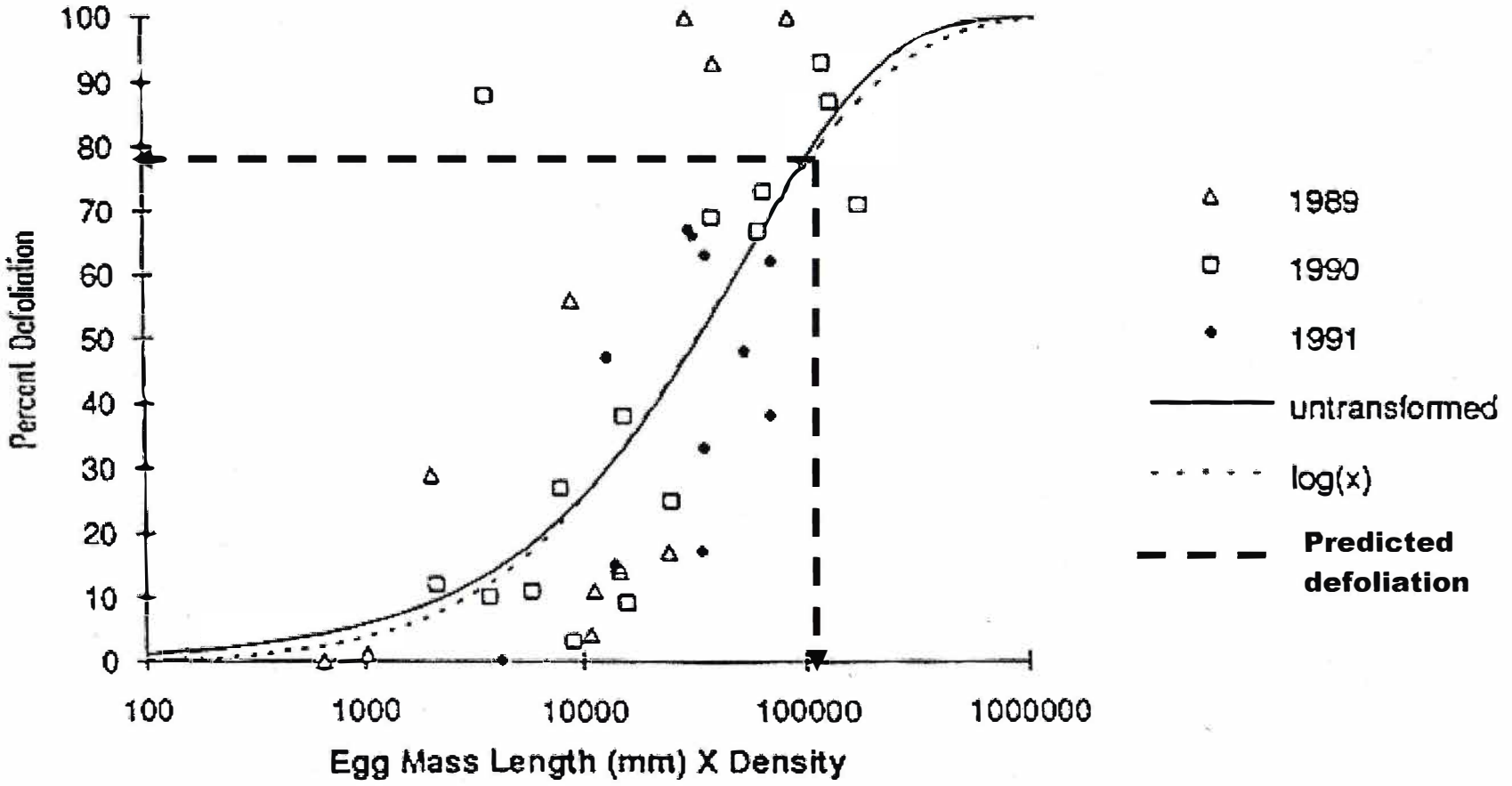


Figure 3. -- Areas where defoliation is likely at Lakehurst Naval Air Engineering Center in 2009/Recommended t

treatment areas.

Figure 4.—Predicted defoliation around the golf course at Lakehurst Naval Air Engineering Center in 2009.



Scatter plot of the product of mean egg mass length and egg mass density versus mean defoliation. Extracted from Liebhold et al. (1993).

USDA United States Department of Agriculture | Forest Service | Northeastern Area State and Private Forestry | 180 Canfield Street Morgantown, WV 26505-3101

File Code: 3400
Date: December 5, 2008

Mr. John Joyce
Naval Air Engineering Center
U.S. Navy
Lakehurst, NJ 08733

Dear John:

Enclosed is the gypsy moth biological evaluation for Lakehurst Naval Air Engineering Center.

In brief, gypsy moth populations are sufficient to cause defoliation on 420 acres. We are recommending a single application of *Bacillus thuringienis* variety *kurstaki* (*Btk*) on six areas encompassing 420 acres. With good timing and proper application, gypsy moth defoliation should be minimal at Lakehurst Naval Air Engineering Center in 2009.

The results from the 2008 gypsy moth project were good. Gypsy moth populations were reduced 88.9% and less than one acre of defoliation was detected within the treatment areas.

The current plans are for the New Jersey Department of Agriculture to incorporate Lakehurst Naval Air Engineering Center in their suppression program again in 2009.

Please contact me at 304-285-1555 if you have any questions regarding this gypsy moth biological evaluation.

Sincerely,

Rodney L. Whiteman

RODNEY L. WHITEMAN
Forester
Forest Health Protection

Enclosure

cc: Joe Zoltowski, NJDA
George Koeck, NJDF
Pete J. Egan, Armed Forces Board
Robert Lueckel, MFO

RLW/blm